CLAIMS

1. A piezoelectric thin film of perovskite crystals represented by a general formula $Pb_{(1-x)}La_x(Zr_yTi_{1-y})O_3$ (where $0 \le x < 1$, $0.05 \le y \le 1$),

wherein a film thickness of the piezoelectric thin film is 1000 nm or more and 4000 nm or less,

the surface of the piezoelectric thin film includes crystal grains having an equivalent circle diameter of 200 nm or more, and those having an equivalent circle diameter of 40 nm or less, and

the number of the crystal grains observed in the surface of the piezoelectric thin film and having the equivalent circle diameter of 40 nm or less is 5% or more with respect to the total number of the crystal grains observed in the surface of the piezoelectric thin film.

2. The piezoelectric thin film according to claim 1, wherein the crystal grains observed in the surface of the piezoelectric thin film and having the equivalent circle diameter of 200 nm or more are columnar crystals grown from a substrate.

3. The piezoelectric thin film according to claim 1, wherein the number of the crystal grains observed in the surface of the piezoelectric thin film and having the equivalent circle diameter of 200 nm or more is 5% or more with respect to the total

number of the crystal grains observed in the surface of the piezoelectric thin film.

4. The piezoelectric thin film according to claim 1, wherein any of the crystal grains observed in the surface of the piezoelectric thin film has an equivalent circle diameter of 1000 nm or less.

5. The piezoelectric thin film according to claim 1, wherein a peak value of an equivalent circle diameter distribution of the crystal grains observed in the surface of the piezoelectric thin film is 50 nm or more and 200 nm or less.

6. The piezoelectric thin film according to claim 1, wherein the surfaces of adjacent crystal grains closely contact each other in the surface of the piezoelectric thin film.

7. A method of manufacturing a piezoelectric thin film, comprising the steps of:

repeating, a plurality of times,

(a) a step of applying a raw material solution containing titanium, zirconium, and lead on a substrate to thereby form a coating layer, and

(b) a step of firing the coating layer at a temperature of 400°C or more and 700°C or less to thereby form a piezoelectric layer having a layer thickness of 150 nm or more and 400 nm or less every time the coating layer is formed to thereby form the piezoelectric thin film in which a plurality of

piezoelectric layers are stacked,

wherein titanium concentration of a raw material solution for use in forming the piezoelectric layer of the first layer is set to be higher than that of a raw material solution for use in forming a last piezoelectric layer.

8. The method of manufacturing the piezoelectric thin film according to claim 7, comprising the steps of repeating the steps (a) and (b) three times or more and ten times or less to thereby form the piezoelectric thin film in which the plurality of piezoelectric layers are stacked.

9. The method of manufacturing the piezoelectric thin film according to claim 7, wherein the raw material solution contains 1,8-diazabicyclo[5.4.0]-7-undecene, 1,5-diazabicyclo[4.3.0]non-5-en, or 1,4-diazabicyclo[2.2.2]octane as a stabilizer.

10. A piezoelectric thin film of perovskite crystals formed on a substrate by a sol-gel process and represented by a general formula $Pb_{(1-x)}La_x(Zr_yTi_{1-y})O_3$ (where $0 \le x < 1$, $0.05 \le y \le 1$),

wherein a film thickness of the piezoelectric thin film is 1000 nm or more and 4000 nm or less, and

a difference between a maximum value and a minimum value of y in an arbitrary portion of the piezoelectric thin film is 0.05 or less.

11. The piezoelectric thin film according to claim 10, wherein the sol-gel process is the manufacturing method according to claim 7.

12. The piezoelectric thin film according to claim 10, wherein a crystal system in an arbitrary portion of the piezoelectric thin film is the same.

13. The piezoelectric thin film according to claim 12, wherein the crystal system is a tetragonal system, and has a crystal structure whose (100) face of the crystals is oriented in a film thickness direction.

14. The piezoelectric thin film according to claim 12, wherein the crystal system is an rhombohedral system, and has a crystal structure whose (111) face of the crystals is oriented in a film thickness direction.

15. A piezoelectric element comprising: a piezoelectric thin film held between lower and upper electrodes, the piezoelectric thin film comprising the piezoelectric thin film according to claim 1.

16. A piezoelectric actuator comprising: the piezoelectric element according to claim 15 as a driving source.

17. An ink jet system recording head comprising: an ink discharge port; a pressure chamber communicating with the ink discharge port; a vibration plate constituting a part of the pressure

chamber; and a piezoelectric element for imparting vibration to a vibration plate disposed outside the pressure chamber, the ink discharge port discharging ink in the pressure chamber by a volume change in the pressure chamber generated by the vibration plate, wherein the piezoelectric element comprises the piezoelectric element according to claim 15.